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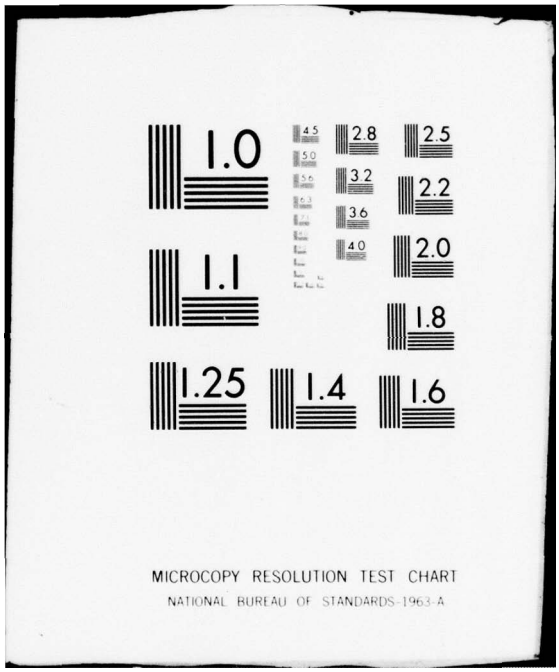
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1.1
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MICROCOPY RESOLUTION TEST CHART
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FAA-RD-78-140

LEVEL II

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75th ANNIVERSARY OF POWERED FLIGHT · 1903-1978 ·

FEDERAL AVIATION ADMINISTRATION FLIGHT SERVICE STATION EMERGENCY SERVICES PROGRAM

IIT Research Institute
Under Contract to
DEPARTMENT OF DEFENSE
Electromagnetic Compatibility Analysis Center
Annapolis, Maryland 21402

AUGUST 1978

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, DC 20590

NOTICE

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(16) 649E

16. Abstract

Program, formats and outputs are described that were developed and produced by ECAC for the Federal Aviation Administration. These programs can be used to describe the existing LOS coverage area of FAA direction-finding stations, airport surveillance radars, and air route surveillance radars, in the conterminous United States.

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PREFACE

The Electromagnetic Compatibility Analysis Center (ECAC) is a Department of Defense facility, established to provide advice and assistance on electromagnetic compatibility matters to the Secretary of Defense, the Joint Chiefs of Staff, the military departments and other DoD components. The center, located at North Severn, Annapolis, Maryland 21402, is under policy control of the Assistant Secretary of Defense for Communication, Command, Control, and Intelligence and the Chairman, Joint Chiefs of Staff, or their designees, who jointly provide policy guidance, assign projects, and establish priorities. ECAC functions under the executive direction of the Secretary of the Air Force and the management and technical direction of the Center are provided by military and civil service personnel. The technical operations function is provided through an Air Force sponsored contract with the IIT Research Institute (IITRI).

This report was prepared for the Systems Research and Development Service of the Federal Aviation Administration in accordance with Interagency Agreement DOT-FA70WAI-175, as part of AF Project 649E under Contract F-19628-78-C-0006, by the staff of the IIT Research Institute at the Department of Defense Electromagnetic Compatibility Analysis Center.

To the extent possible, all abbreviations and symbols used in this report are taken from American Standards Y10.19 (1967) "Units Used in Electrical Science and Electrical Engineering" issued by the USA Standards Institute.

FRANKLIN ATWELL
Project Engineer, IITRI

WILLIAM SCHUMMER
Assistant Director
Contractor Operations

Approved by:

THOMAS A. ANDERSON
Colonel, USAF
Director

M. A. SKEATH
Special Projects
Deputy Director

ENGLISH/METRIC CONVERSION FACTORS

LENGTH

From \ To	cm	m	km	in	ft	mi	nmi
cm	1	0.01	$1x10^{-5}$	0.3937	0.0328	$6.21x10^{-6}$	$5.39x10^{-6}$
m	100	1	0.001	39.37	3.281	0.0006	0.0005
km	100,000	1000	1	39370	3281	0.6214	0.5395
in	2.540	0.0254	$2.54x10^{-5}$	1	0.0833	$1.58x10^{-5}$	$1.37x10^{-5}$
ft	30.48	0.3048	$3.05x10^{-4}$	12	1	$1.89x10^{-4}$	$1.64x10^{-4}$
mi	160,900	1609	1.609	63360	5280	1	0.8688
nmi	185,200	1852	1.852	72930	6076	1.151	1

AREA

From \ To	cm^2	m^2	km^2	in^2	ft^2	mi^2	nmi^2
cm^2	1	0.0001	$1x10^{-10}$	0.1550	0.0011	$3.86x10^{-11}$	$5.11x10^{-11}$
m^2	10,000	1	$1x10^{-6}$	1550	10.76	$3.86x10^{-7}$	$5.11x10^{-7}$
km^2	$1x10^{10}$	$1x10^{6}$	1	$1.55x10^{9}$	$1.08x10^{7}$	0.3861	0.2914
in^2	6.452	0.0006	$6.45x10^{-10}$	1	0.0069	$2.49x10^{-10}$	$1.88x10^{-10}$
ft^2	929.0	0.0929	$9.29x10^{-8}$	144	1	$3.59x10^{-8}$	$2.71x10^{-8}$
mi^2	$2.59x10^{10}$	$2.59x10^{6}$	2.590	$4.01x10^{9}$	$2.79x10^{7}$	1	0.7548
nmi^2	$3.43x10^{10}$	$3.43x10^{6}$	3.432	$5.31x10^{9}$	$3.70x10^{7}$	1.325	1

VOLUME

From \ To	cm^3	liter	m^3	in^3	ft^3	yd^3	fl. oz.	fl. pt.	fl. qt.	gal.
cm^3	1	0.001	$1x10^{-6}$	0.0610	$3.53x10^{-5}$	$1.31x10^{-6}$	0.0338	0.0021	0.0010	0.0002
liter	1000	1	0.001	61.02	0.0353	0.0013	33.81	2.113	1.057	0.2642
m^3	$1x10^{6}$	1000	1	61,000	35.31	1.308	33,800	2113	1057	264.2
in^3	16.39	0.0163	$1.64x10^{-5}$	1	0.0006	$2.14x10^{-5}$	0.5541	0.0346	2113	0.0043
ft^3	28,300	28.32	0.0283	1728	1	0.0370	957.5	59.84	0.0173	7.481
yd^3	765,000	764.5	0.7646	46700	27	1	25900	1616	807.9	202.0
fl. oz.	29.57	0.2957	$2.96x10^{-5}$	1.805	0.0010	$3.87x10^{-5}$	1	0.0625	0.0312	0.0078
fl. pt.	473.2	0.4732	0.0005	28.88	0.0167	0.0006	16	1	0.5000	0.1250
fl. qt.	948.4	0.9463	0.0009	57.75	0.0334	0.0012	32	2	1	0.2500
gal.	3785	3.785	0.0038	231.0	0.1337	0.0050	128	8	4	1

MASS

From \ To	g	kg	oz	lb	ton
g	1	0.001	0.0353	0.0022	$1.10x10^{-6}$
kg	1000	1	35.27	2.205	0.0011
oz	28.35	0.0283	1	0.0625	$3.12x10^{-5}$
lb	453.6	0.4536	16	1	0.0005
ton	907,000	907.2	32,000	2000	1

TEMPERATURE

°F = 5/9 (°C - 32)

°C = 9.5 (°F) + 32

FEDERAL AVIATION ADMINISTRATION
SYSTEMS RESEARCH AND DEVELOPMENT SERVICE
SPECTRUM MANAGEMENT STAFF

STATEMENT OF MISSION

The mission of the Spectrum Management Staff is to assist the Department of State, National Telecommunications and Information Administration, and the Federal Communications Commission in assuring the FAA's and the nation's aviation interests with sufficient protected electromagnetic telecommunications resources throughout the world to provide for the safe conduct of aeronautical flight by fostering effective and efficient use of a natural resource--the electromagnetic radio-frequency spectrum.

This objective is achieved through the following services:

- Planning and defending the acquisition and retention of sufficient radio-frequency spectrum to support the aeronautical interests of the nation, at home and abroad, and spectrum standardization for the world's aviation community.

- Providing research, analysis, engineering, and evaluation in the development of spectrum related policy, planning, standards, criteria, measurement equipment, and measurement techniques.

- Conducting electromagnetic compatibility analyses to determine intra/inter-system viability and design parameters, to assure certification of adequate spectrum to support system operational use and projected growth patterns, to defend the aeronautical services spectrum from encroachment by others, and to provide for the efficient use of the aeronautical spectrum.

- Developing automated frequency-selection computer programs/routines to provide frequency planning, frequency assignment, and spectrum analysis capabilities in the spectrum supporting the National Airspace System.

- Providing spectrum management consultation, assistance, and guidance to all aviation interests, users, and providers of equipment and services, both national and international.

EXECUTIVE SUMMARY

The FAA has been sponsoring a series of projects at ECAC to evaluate existing coverage of NAVAID and air-traffic-control facilities in the conterminous United States. As a result of these projects, a series of computer programs have been developed. The first program extracts location data from selected ECAC E-File records and creates a facilities file. The second program constructs terrain profiles from each facility on the facilities file to each waypoint location within range and calculates the line-of-sight minimum reception altitude (MRA) over the waypoint.[a] The third program combines the output of each run of the second program into a waypoint-facility records library. The fourth program selects from the waypoint-facility records library and produces waypoint coverage listings and high-speed-printer coverage plots for up to 10 altitudes as well as a least-MRA plot. In addition, a tape is produced that contains data from the least-MRA plot for the fifth program. The fifth program produces a scaled and projection-adjusted map-overlay tape for use with the Calcomp plotter. The map overlay thus produced depicts line-of-sight coverage contours for 10 altitudes using 3 colors.

[a] Waypoints are intersections in a 15-minute latitude/longitude grid system that covers the conterminous U.S.

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SECTION 1

INTRODUCTION

BACKGROUND

The Federal Aviation Administration, Flight Information Services Division, is in the process of developing plans and specifications for the modernization of the Flight Service Station (FSS) system. One portion of this effort is the FSS emergency services program. This program will determine the line-of-sight (LOS) coverage of existing emergency location devices; in particular, the Airport Surveillance Radars (ASR's) the Air Route Surveillance Radars (ARSR's) and the Direction Finders (DF's). This LOS analysis considers only terrain characteristics and earth curvature (4/3 radius). Limits to LOS coverage are made using an effective range estimate for each type of facility, to simulate the effects of receiver sensitivity and transmitter effective radiated power. The coverage information will be used to determine areas in the continental United States where either no coverage or redundant coverage exists. In this manner, holes in the emergency services coverage can be eliminated. (This program utilizes the capabilities developed by ECAC.[1])

OBJECTIVES

The objectives of this task were:

1. To provide data that depicts the CONUS areas within line-of sight of existing airport surveillance radars (ASR's) air route surveillance radars (ARSR's), and DF stations,
2. To summarize and display the LOS coverage of the DF facilities, in order to facilitate management decisions.

---

[1]Atwell, F., *FAA VHF Air/Ground Data Link & Flight Service/System Communications Analysis*, FAA-RD-76-38, Department of Transportation, Washington, DC, ECAC Report No. ECAC-PR-76-014, March 1976.

APPROACH

The programs developed by ECAC for the FSS project were used to determine the LOS coverage of existing DF facilities. Modification of the program that generates the high-speed-printer (HSP) plots of coverage was necessary to provide an enhanced waypoint-facility record-selection capability and to accommodate LOS coverage at up to 10 specified altitudes. An additional program was added to the system (Program 5) that will:

1. Provide scaled, plotter-produced map overlays in three colors, and
2. Modify (adjust) these overlays to fit Lambert conformal map projections.

SECTION 2

PROGRAM DESCRIPTION AND OUTPUTS

The five system programs are depicted in FIGURE 1; Program 5 was added during the effort described herein. These programs are used to calculate and display the minimum reception altitude (MRA) of a facility at each waypoint within a predetermined range of the facility. Waypoints are the intersections of a 15-minute latitude/longitude grid system that covers the conterminous U.S. and comprises approximately 15,000 waypoints. The facility data for this project was taken from the ECAC environmental data base of information on FAA and Air Force navigational aids. A functional description of each of the five programs in the system follows.

PROGRAM 1

Program 1 selects records from a tape file of selected ECAC environmental records (E-File) based upon criteria of latitude and longitude for the geographic area to be considered. Each record is classified as to type and class of facility. The types for this project are DF and radar. For the DF's, classes are: UHF and VHF; for radars, classes are ASR and ARSR. After classification, the data fields pertaining to facility call sign, latitude, longitude, site elevation, and antenna height are extracted, converted to fieldata format, and written onto tape as a 48-character record.

PROGRAM 2

The tape created by Program 1 contains the input data for Program 2. In Program 2, the classification of each facility record is examined and a profiling distance is assigned according to the

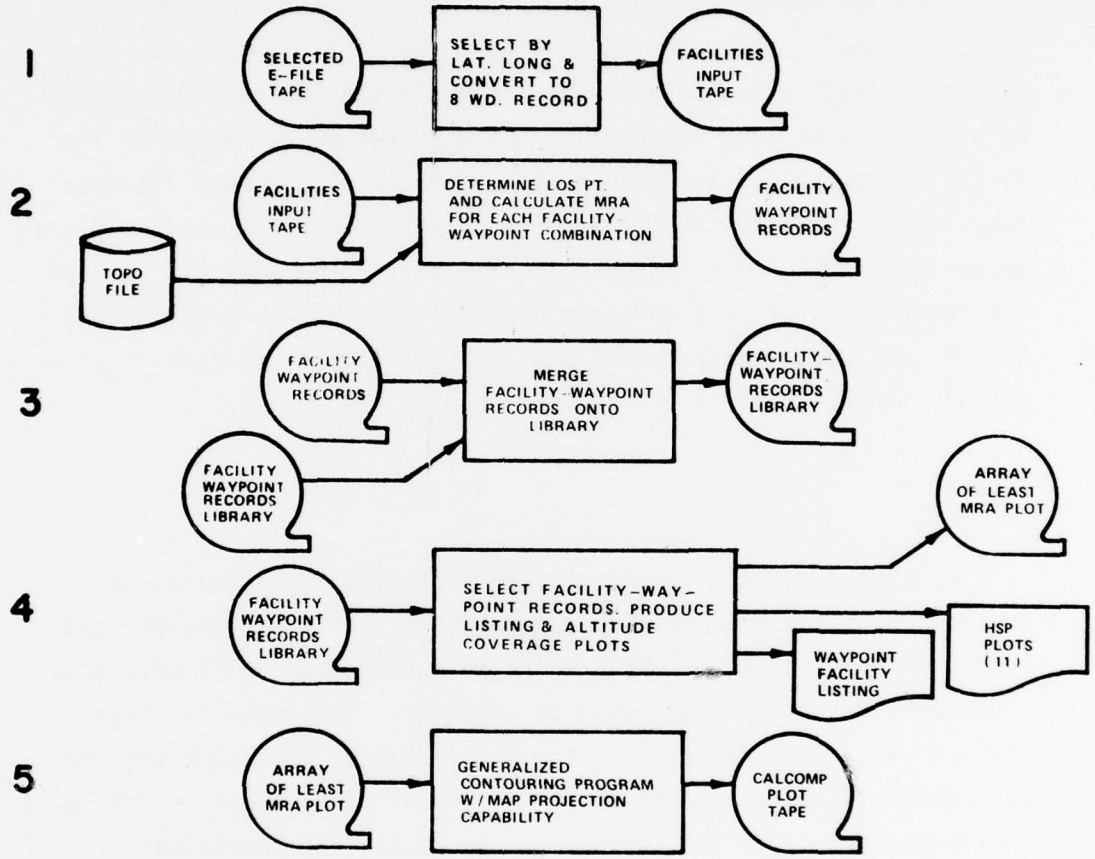

FIGURE 1. GENERAL ILLUSTRATION OF PROGRAMS.

type and class of the facility (DF's 100 mi., ASR's 60 mi., and ARSR's 200 mi.). This distance is used to determine which waypoints are within range of the facility. Waypoint locations are calculated using the latitude and longitude of the facility, and a terrain profile is then constructed from the facility to each waypoint. The terrain profile is generated from data in the ECAC topographic data file. This file is a compilation of terrain elevations, taken from 1:250,000-scale maps at 30-second intervals of latitude and longitude, and stored in blocks of 1° by 1° of latitude and longitude. The terrain profile consists of terrain elevations computed by interpolation of terrain data at specified increments (usually 30 seconds) along the profiling path. Each elevation is adjusted to correct for refractivity, and the vertical angle from the site elevation to each terrain elevation point is calculated. The angles for the entire profile are compared and the greatest LOS angle (θ max, FIGURE 2) is used to calculate the minimum reception altitude (MRA) at the waypoint. The MRA is defined as the lowest altitude above a waypoint that is within line-of-sight of the facility. A record is written on tape for each facility-waypoint combination processed by the program. This record contains the waypoint ID (abbreviated latitude, longitude code), facility call sign, class and type of facility, latitude and longitude of the facility, site elevation of the facility, true bearing and distance from the facility to the waypoint, the MRA, and the elevation of the terrain at the waypoint. A flow chart for this program is shown in FIGURE 3. All records on the output tape are in sort order by waypoint ID and call sign.

PROGRAM 3

The third program provides the capability to merge the output tapes of Program 2 onto a sorted, facility-waypoint records-library tape containing the combined results of all the runs made with Program 2.

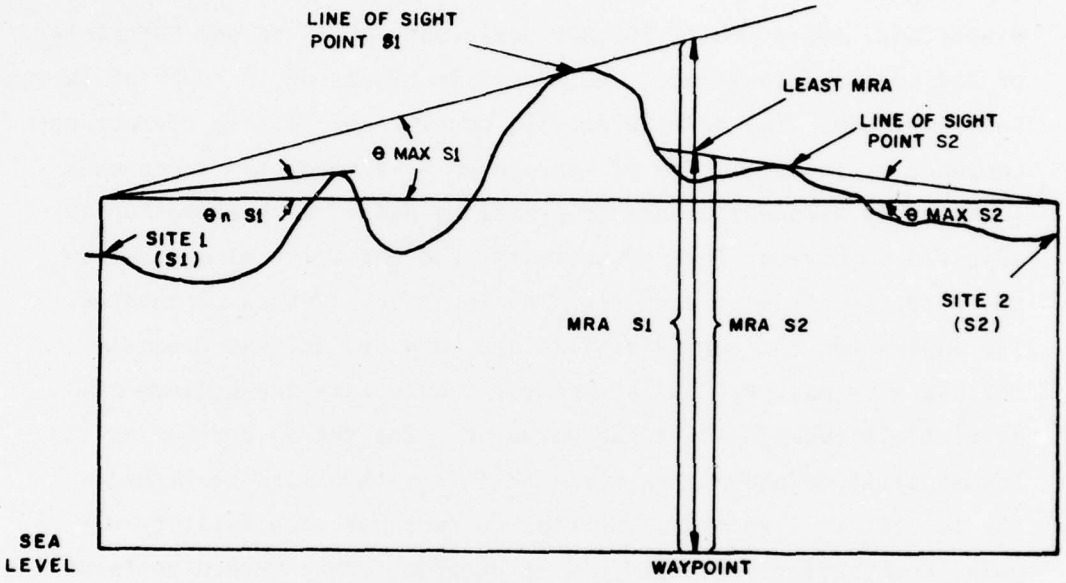

FIGURE 2. ILLUSTRATION OF GREATEST LOS ANGLE, MRA, AND LEAST MRA.

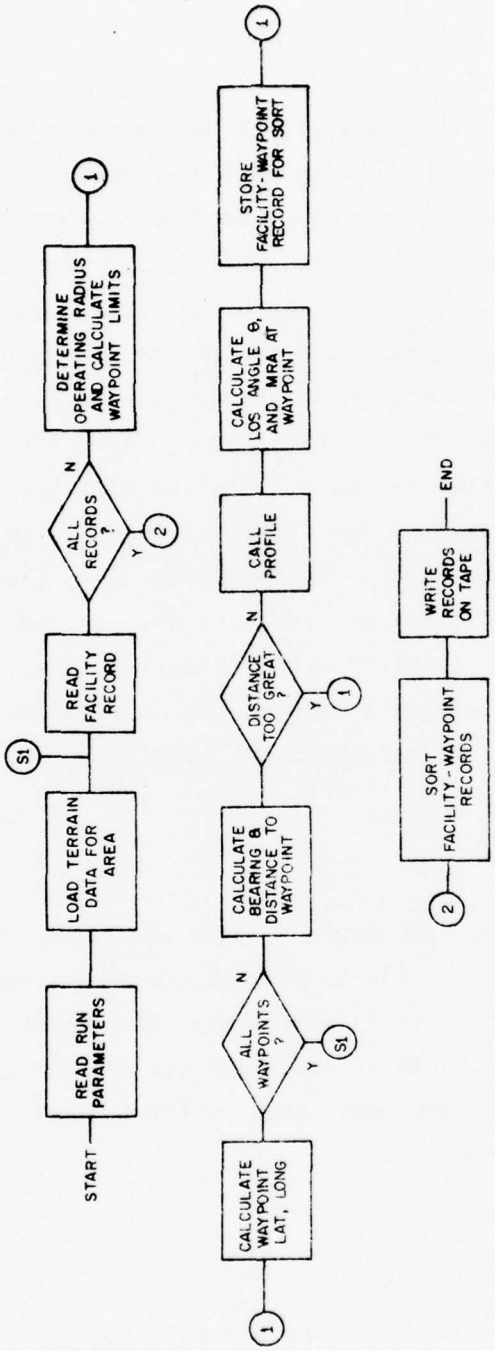

FIGURE 3. FLOWCHART OF PROGRAM 2.

PROGRAM 4

Program 4 provides the capability of selecting records from the facility-waypoint records-library tape produced by Program 3 according to constraints of geography (latitude, longitude), site I.D., type, class, and owner. Several options for the output may be specified. The selected records can be listed in order of waypoint ID, and/or the program will use these records to generate high-speed printer plots of waypoint coverage in the geographic area bounded by the latitude and longitude constraints used for selection. Each plot indicates waypoint coverage at a specified altitude above sea level, by a facility, where the MRA at the waypoint is less than or equal to this specified altitude. There may be up to ten altitudes specified. An eleventh plot is provided which shows the least MRA at each waypoint from any facility within range of that waypoint. The numerical values of least MRA may also be written onto a tape that can be used to produce scaled Calcomp overlays.

PROGRAM 5

The fifth program uses the tape of least MRA values to produce a tape that will control the Calcomp plotter during production of LOS coverages contour for up to 10 altitudes. The capability exists to also modify the output in terms of scale,and for Lambert Conformal map projection,so that the plot generated by the Calcomp plotter can be used as a map overlay.

TYPICAL OUTPUTS

A waypoint coverage listing can be provided for each area, to show the waypoint identification and, for each facility within range, the facility ID, class and type of the facility, latitude and longitude

of the facility, site elevation, true bearing from the facility to the waypoint, distance to the waypoint, the altitude of the terrain at the waypoint, and the minimum reception altitude MRA over the waypoint that is within line-of-sight of the facility (see FIGURE 4). For the purposes of this project, the U.S. is divided into 11 areas (see FIGURE 5) and for each area there will be waypoint coverage plots for 10 FAA-specified altitudes (1,000'-10,000') showing which waypoints have coverage at each altitude (see FIGURE 6). Where the MRA for a waypoint is within 1,000' of the terrain, a special marker (#) is printed. Waypoints that are not covered are indicated by an asterisk(*). An overall waypoint coverage plot (see FIGURE 7) was produced to show the least MRA at each waypoint. A number is printed at each waypoint to indicate the least MRA in thousands of feet (i.e., 1, 2, 3, etc.). The information contained in the least MRA plot is reproduced in contour form, scaled and adjusted for map projection (see FIGURE 8). This contour plot is generally drawn on vellum in 3 colors (black, red, green) for use as an overlay on a map or chart.

The basic records have been stored at ECAC on tape provided by the FAA, and will provide the FAA with a waypoint coverage library for future use.

THE FOLLOWING IS A LISTING OF THE FACILITY WAYPOINT RECORDS SHOWING THE MINIMUM RECEPTION ALTITUDE AT THE WAYPOINT FOR THE NAMED FACILITY. THESE RECORDS WERE USED TO DETERMINE THE ALTITUDE COVERAGE SHOWN IN COVERAGE PLOTS 1-10.

WAYPOINT IDENTIFIER = WAYPOINT IDENTIFICATION, 1ST TWO CHARACTERS LATITUDE IN DEGREES
3D CHARACTER MINUTES CODE, BLANK=00 MIN, A=15 MIN, B=30 MIN, C=45 MIN
4TH CHARACTER LAT-LONG SEPARATOR
5TH-7TH CHARACTERS LONGITUDE DEGREES
8TH CHARACTER MINUTES CODE, SAME AS THIRD CHARACTER

FAC ID = FACILITY CALL SIGN

CLASS = CLASSIFICATION OF FACILITY, L=LMM/CO, V=VOICE, H=TWR, T=FSS, H=HI/CO, S=SFO, O=L/MF, E=EMERGENCY FREQ 121.5
I=ARSR, Z=ASR, A=VHF, B=UHF

TYPE = FACILITY TYPE, 1 = VOR, 2 = TACAN, 3 = VOR/TAC, 4 = DME, 5 = COMM, 6 = DF, 7 = RADAR

O/A=OPERATING AGENCY, A=AIRFORCE, F=FAA, N=NAVY, H=HARRT, O=OTHER

FACILITY LATITUDE-LONGITUDE = GEOGRAPHICAL LOCATION OF THE FACILITY

SITE ELEV = TERRAIN ELEVATION AT THE FACILITY IN FEET

BEARING = TRUE BEARING FROM THE FACILITY TO THE WAYPOINT IN DEGREES

DISTANCE = DISTANCE FROM THE FACILITY TO THE WAYPOINT IN MILES

MRA = MINIMUM RECEPTION ALTITUDE OVER THE WAYPOINT TO BE WITHIN RADIO LINE OF SIGHT OF THE FACILITY

FLAG = A CHARACTER IN THIS COLUMN INDICATES THAT TERRAIN DATA FOR THIS PROFILE WAS MISSING

WPELEV = ELEVATION OF TERRAIN AT WAYPOINT

WAYPOINT ID	FAC ID	CLASS	TYPE	O/A	FACILITY LAT&TUDE	FACILITY LONGITUDE	SITE ELEV	BEARING FAC-WYPT	DISTANCE FAC-WYPT	MRA	FLAG	WPELEV
38 / 73R	SBY	A	6	F	38.3455A	75+52495	52	101.6	97.9	10149		0
38 / 73C	ACY	A	6	F	39.4569A	74+58456	70	155.6	95.8	5368		0
38 / 73C	SBY	A	6	F	38.3455A	75+52495	52	103.3	86.9	8313		0
38 / 74	ACY	A	6	F	39.4569A	74+58456	70	162.9	91.7	4904		0
38 / 74	SBY	A	6	F	38.3455A	75+52495	52	105.6	75.0	6638		0
38 / 74A	ACY	A	6	F	39.4569A	74+58456	70	169.7	88.9	4540		0
38 / 74A	SBY	A	6	F	38.3455A	75+52495	52	108.6	83.7	5125		0
38 / 74R	ACY	A	6	F	39.4569A	74+58456	70	177.9	87.6	4344		0
38 / 74R	SBY	A	6	F	38.3455A	75+52495	52	112.9	52.7	3793		0
38 / 74C	SBY	A	6	F	38.3455A	75+52495	52	119.3	42.1	2692		0
38 / 74C	ACY	A	6	F	39.4569A	74+58456	70	185.1	87.8	4333		0
38 / 74C	ORF	A	6	F	36.89500	76+20472	26	95.8	96.0	5699		0
38 / 75	SBY	A	6	F	38.3455A	75+52495	52	129.7	32.9	1715		0
38 / 75	ACY	A	6	F	39.4569A	74+58456	70	192.6	89.6	4680		0
38 / 75	ORF	A	6	F	36.89500	76+20472	26	90.5	87.8	5696		0
38A/ 73A	ACY	A	6	F	39.4569A	74+58456	70	138.8	95.7	5269		0
38A/ 73M	ACY	A	6	F	39.4569A	74+58456	70	144.7	88.5	4536		0
38A/ 73B	SBY	A	6	F	38.3455A	75+52495	52	92.7	95.7	9791		0
38A/ 73C	ACY	A	6	F	39.4569A	74+58456	70	151.4	82.3	3895		0
38A/ 73C	SBY	A	6	F	38.3455A	75+52495	52	93.3	83.9	7990		0
38A/ 74	ACY	A	6	F	39.4569A	74+58456	70	159.1	77.5	3936		0
38A/ 74	SBY	A	6	F	38.3455A	75+52495	52	94.1	72.2	6289		0
38A/ 74A	ACY	A	6	F	39.4569A	74+58456	70	167.7	74.2	3096		0
38A/ 74A	SBY	A	6	F	38.3455A	75+52495	52	95.0	60.9	4799		0
38A/ 74R	SBY	A	6	F	38.3455A	75+52495	52	96.4	48.7	3511		0
38A/ 74R	ACY	A	6	F	39.4569A	74+58456	70	176.8	72.6	2920		0
38A/ 74R	ILG	A	6	F	39.67472	75+59461	78	148.7	99.7	6486		0
38A/ 74C	SBY	A	6	F	38.3455A	75+52495	52	98.7	37.1	2402		0
38A/ 74C	ACY	A	6	F	39.4569A	74+58456	70	186.1	72.9	2965		0
38A/ 74C	ILG	A	6	F	39.67472	75+59461	78	154.9	99.3	5797		0
38A/ 75	SBY	A	6	F	38.3455A	75+52495	52	102.8	25.5	1455		0
38A/ 75	ACY	A	6	F	39.4569A	74+58456	70	195.1	75.0	3214		0
38A/ 75	ORF	A	6	F	36.89500	76+20472	26	34.8	99.6	6089		0
38A/ 75	ILG	A	6	F	39.67472	75+59461	78	161.7	90.0	5284		0
38B/ 73	ACY	A	6	F	39.4569A	74+58456	70	127.3	93.7	4962		0
38B/ 73A	ACY	A	6	F	39.4569A	74+58456	70	132.2	84.8	4003		0
38B/ 73B	ACY	A	6	F	39.4569A	74+58456	70	138.2	76.6	3280		0
38B/ 73B	SBY	A	6	F	38.3455A	75+52495	52	83.8	95.8	9805		0
38B/ 73C	ACY	A	6	F	39.4569A	74+58456	70	145.6	69.4	2712		0
38B/ 73C	SBY	A	6	F	38.3455A	75+52495	52	83.1	84.1	7978		0
38B/ 74	ACY	A	6	F	39.4569A	74+58456	70	154.4	63.6	2248		0
38B/ 74	SBY	A	6	F	38.3455A	75+52495	52	82.2	72.4	6312		0
38B/ 74A	ACY	A	6	F	39.4569A	74+58456	70	164.6	59.6	1950		0
38B/ 74A	SBY	A	6	F	38.3455A	75+52495	52	80.8	60.8	9896		0
38B/ 74A	ILG	A	6	F	39.67472	75+59461	78	137.9	94.5	5712		0
38B/ 74R	SBY	A	6	F	38.3455A	75+52495	52	78.8	49.2	3560		0
38B/ 74R	ACY	A	6	F	39.4569A	74+58456	70	174.0	57.6	1767		0
38B/ 74R	ILG	A	6	F	39.67472	75+59461	78	141.7	97.2	4958		0
38B/ 74R	PNE	A	6	F	40.08000	75+00499	120	165.9	97.8	8029		0
38B/ 74C	SBY	A	6	F	38.3455A	75+52495	52	75.5	37.7	2438		0
38B/ 74C	ACY	A	6	F	39.4569A	74+58456	70	187.7	58.0	1853		0
38B/ 74C	ILG	A	6	F	39.67472	75+59461	78	150.5	80.9	4272		0
38B/ 74C	PNE	A	6	F	40.08000	75+00499	120	172.7	94.6	5837		0
38B/ 75	SBY	A	6	F	38.3455A	75+52495	52	69.3	25.5	1491		0
38B/ 75	ACY	A	6	F	39.4569A	74+58456	70	198.7	60.4	2186		0
38B/ 75	ILG	A	6	F	39.67472	75+59461	78	154.2	75.9	3762		0
38B/ 75	PNE	A	6	F	40.08000	75+00499	120	179.8	94.9	4910		0
38C/ 72C	ACY	A	6	F	39.4569A	74+58456	70	115.8	95.5	9825		0
38C/ 73	ACY	A	6	F	39.4569A	74+58456	70	119.4	85.2	3741		0
38C/ 73A	ACY	A	6	F	39.4569A	74+58456	70	123.9	75.3	3013		0
38C/ 73R	ACY	A	6	F	39.4569A	74+58456	70	129.7	64.0	2326		0
38C/ 73R	SBY	A	6	F	38.3455A	75+52495	52	75.1	98.2	10196		0
38C/ 73C	ACY	A	6	F	39.4569A	74+58456	70	137.2	57.6	1767		0
38C/ 73C	SBY	A	6	F	38.3455A	75+52495	52	73.2	86.9	8334		0
38C/ 73C	PNE	A	6	F	40.08000	75+00499	120	193.5	98.9	15304		0
38C/ 74	ACY	A	6	F	39.4569A	74+58456	70	147.1	50.5	1363		0
38C/ 74	SBY	A	6	F	38.3455A	75+52495	52	70.4	75.7	6659		0
38C/ 74	PNE	A	6	F	40.08000	75+00499	120	199.4	92.5	12007		0
38C/ 74	ILG	A	6	F	39.67472	75+59461	78	126.2	92.8	5128		0
38C/ 74A	ACY	A	6	F	39.4569A	74+58456	70	159.7	45.2	1181		0
38C/ 74A	SBY	A	6	F	38.3455A	75+52495	52	67.4	44.7	5163		0
38C/ 74A	ILG	A	6	F	39.67472	75+59461	78	131.1	91.8	4253		0

FIGURE 4. PARTIAL OUTPUT LISTING OF PROGRAM 4, AREA 11.

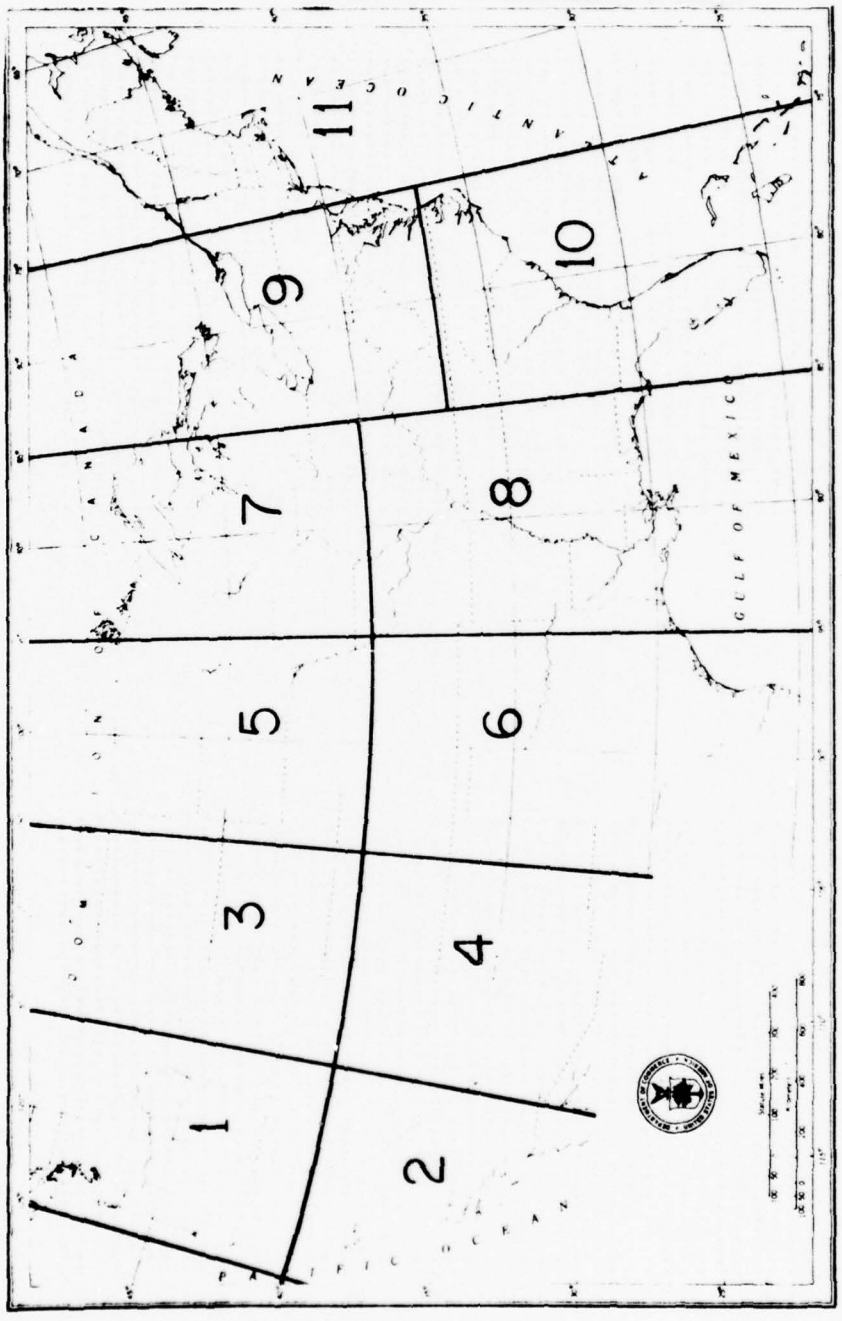

FIGURE 5. MAP OF UNITED STATES SHOWING AREA BOUNDARIES.

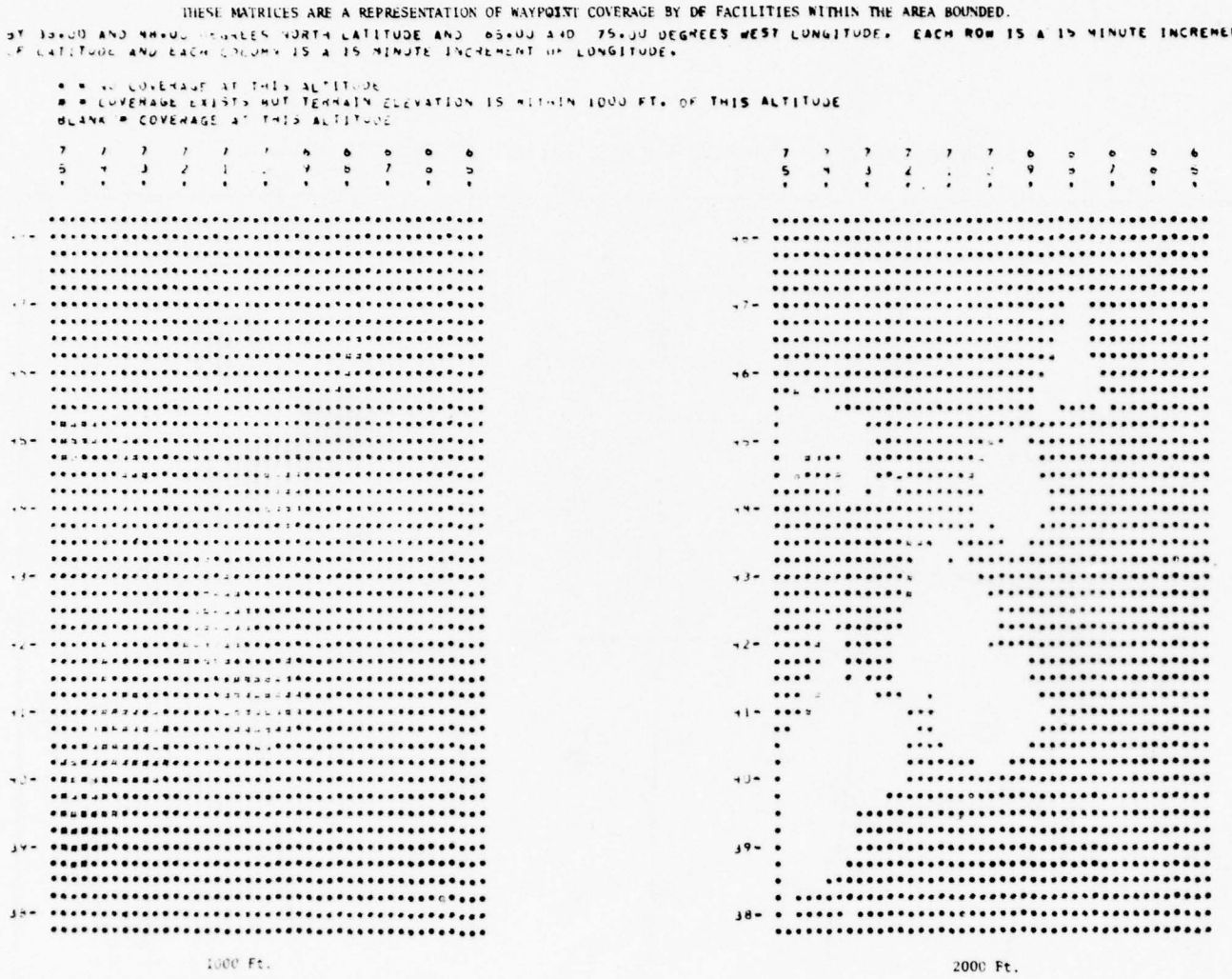

FIGURE 6. HSP COVERAGE PLOTS AT FOUR ALTITUDES FOR AREA XI.
(Page 1 of 2).

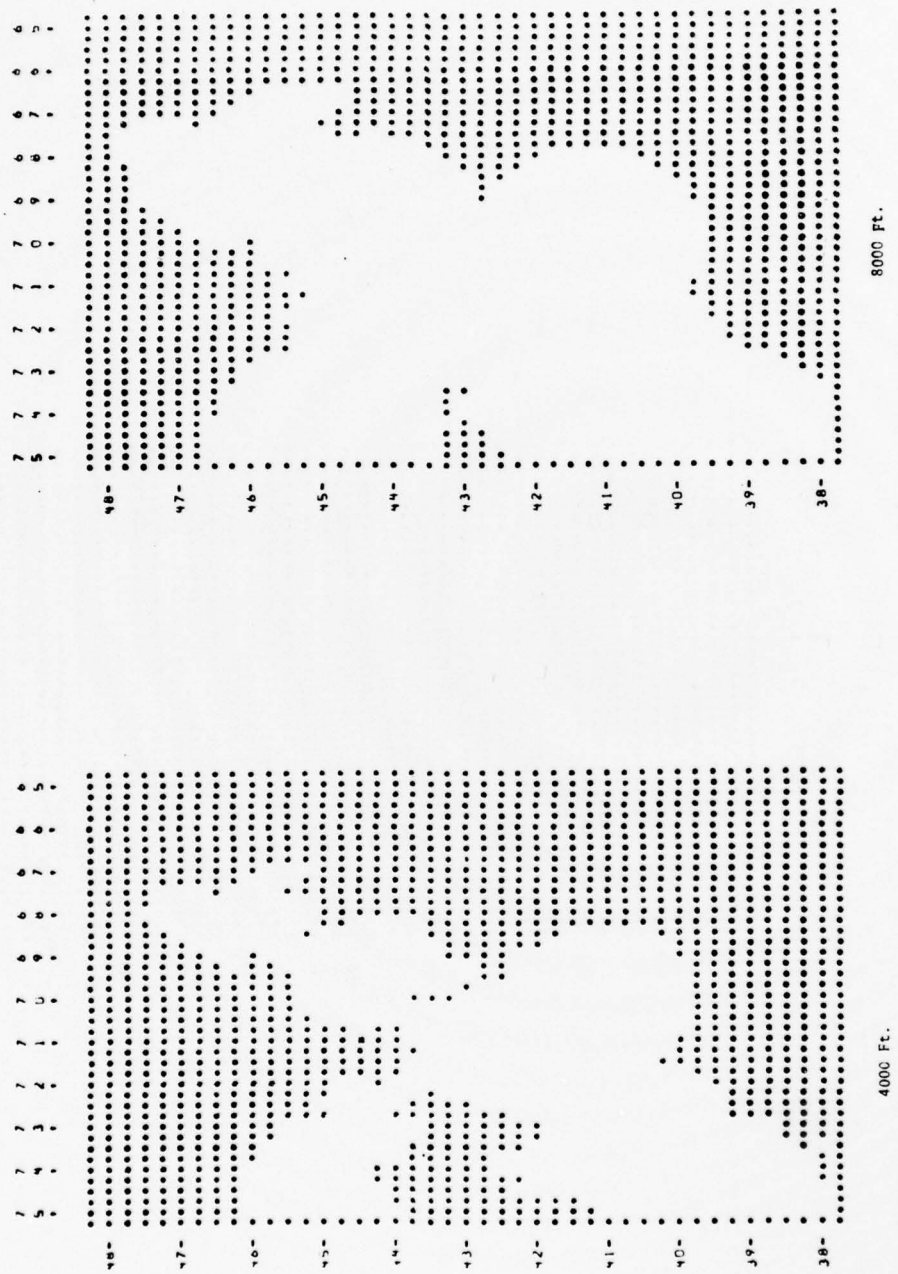

FIGURE 6. (Page 2 of 2).

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THIS MATRIX IS A REPRESENTATION OF THE LEAST MINIMUM RECEPTION ALTITUDE (MRA) WITHIN THE AREA BOUNDED BY 38.00 AND 48.00
DEGREES NORTH LATITUDE AND  65.00 AND  75.00 DEGREES WEST LONGITUDE.  EACH ROW IS A 15 MINUTE INCREMENT OF LATITUDE AND EACH
COLUMN IS A 15 MINUTE INCREMENT OF LONGITUDE.  THE SCALE IS ASFOLLOWS:

1 =     0 -  1000 FT.      8 =  7001 -  8000 FT.      E = 14001 -  15000 FT.
2 =  1001 -  2000 FT.      9 =  8001 -  9000 FT.      F = 15001 -  20000 FT.
3 =  2001 -  3000 FT.      0 =  9001 - 10000 FT.      G = 20001 -  30000 FT.
4 =  3001 -  4000 FT.      A = 10001 - 11000 FT.      H = 30001 -  40000 FT.
5 =  4001 -  5000 FT.      B = 11001 - 12000 FT.      J= 40001 -   50000 FT.
6 =  5001 -  6000 FT.      C = 12001 - 13000 FT.      K = 50001 - 100000 FT.
7 =  6001 -  7000 FT.      D = 13001 - 14000 FT.
```

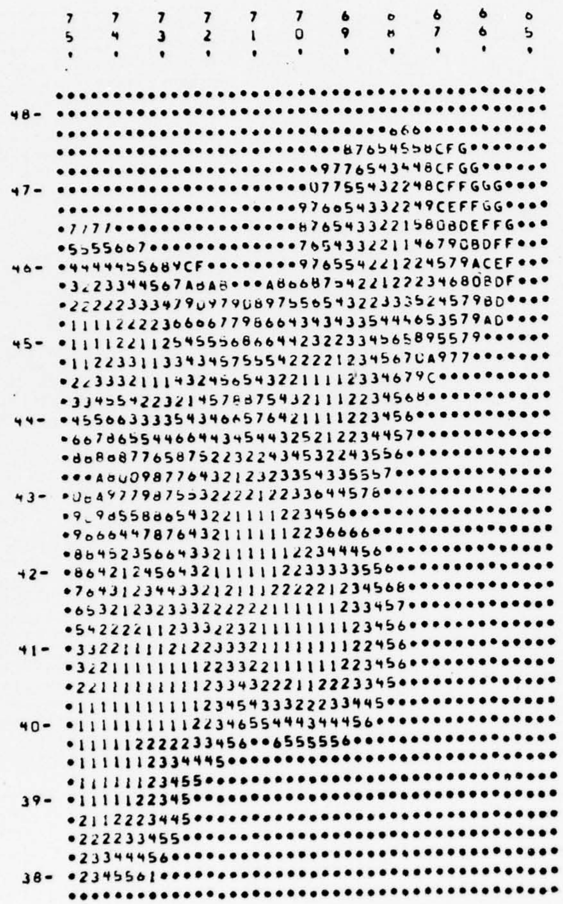

FIGURE 7. LEAST MRA PLOT FOR AREA 11.

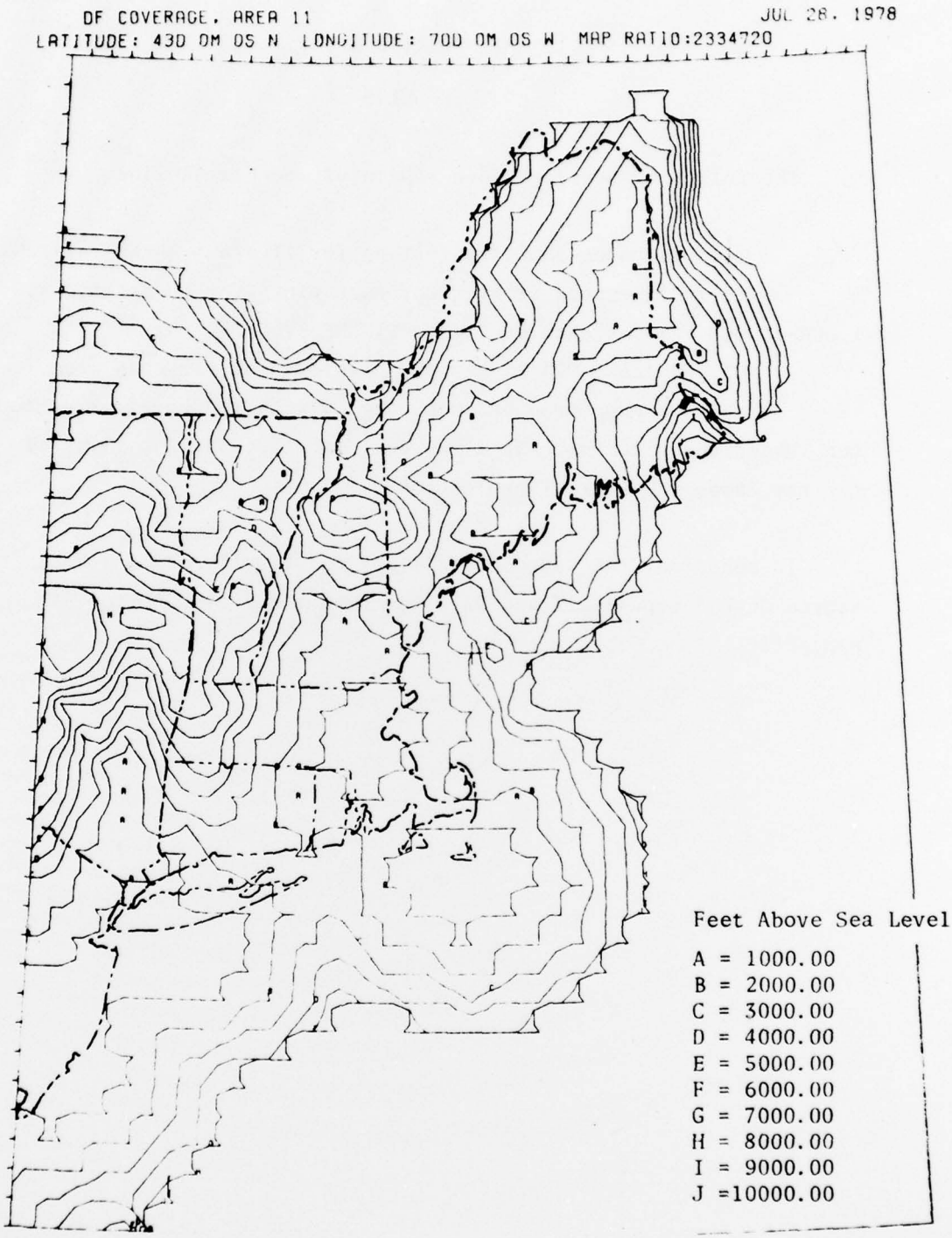

FIGURE 8. LOS COVERAGE CONTOUR OVERLAY FOR AREA 11. (POLITICAL AND GEOGRAPHIC BOUNDARIES ARE NOT PRODUCED ON THE OVERLAY. HERE THEY HAVE BEEN DUBBED IN FOR ILLUSTRATION PURPOSES ONLY).

SECTION 3

RESULTS

The following were provided separately to FAA ARD 461:

1. Waypoint-facility listing for 11 areas shown in FIGURE 5.
2. High-speed printer coverage plots for 10 altitudes, 1,000-10,000 ft. for each area (see FIGURE 8).
3. A least-MRA high-speed printer plot for each area.
4. Calcomp-produced map overlay with LOS coverage contours for 10 altitudes for each at a map scale of 1:2,334,720, adjusted for the Lambert Conformal projection.

In addition, the waypoint-facility records library has been stored on FAA tapes 9213 and 9214 for future use by ECAC for FAA projects.

APPENDIX A

PROGRAM CARD AND RECORD FORMAT DESCRIPTION

This appendix provides the run-parameter formats and input and output record formats for each of the programs described in the report.

PROGRAM 1

The only run parameters necessary for Program 1 are the geographic constraints, in terms of latitude and longitude, of the area within which it is desired to select equipments from the E-File tape. The format of the parameter card is:

Col. 1 - 6	Latitude of northern boundary of area
Col. 7 - 12	Latitude of southern boundary of area
Col. 13 - 18	Longitude of eastern boundary of area
Col. 19 - 29	Longitude of western boundary of area

All values are in decimal degrees and require no sign, since they are assumed to be north latitude and west longitude.

The input data tape (File A) contains selected E-File records ordered by call sign and latitude and longitude. The fields used by this program are call sign, latitude, longitude, site elevation, and operating agency. Records with the same call sign, latitude, and longitude are combined into one output site record.

The output data tape (File B) consists of 8-word fieldata records, 100 to a tape block. These records are in order by call sign, latitude, and longitude. The format of this record is:

Word 1, S1-S4 = Call sign

Word 1, S5 to Word 3, S1 = Site latitude

Word 3, S2 to Word 4, S5 = Site longitude

Word 7 = Site elevation

Word 8, S1-S3 = Site class

Word 8, S4 = Site type

Word 8, S6 = Operating agency of site; A = Air Force, F = FAA, R = Army, N = Navy, O = Other.

The class and type fields contain a special binary code, where a bit in a particular position indicates the class or types of the facility. These fields are used in conjunction with each other. There are seven facility types: VOR, TACAN, VORTAC, DME, COMM, DF and RADAR. The type field contains 6 bits. If the first bit (reading from left to right) is a one, the type is VOR, if bit 2 is a one it is a TACAN. If bits 1 and 2 are both one, the facility is a VORTAC. The meaning of each bit position is -

Type	VOR	TACAN	DME	COMM	DF	RADAR
Bit	1	2	3	4	5	6

The various classes are HIGH, LOW, TERMINAL, LRCO-Limited Remote Control Outlet, VOICE-Voice Channel on VOR, TWEB-Terminal Weather Broadcast, EFAS - Enroute Flight Advisory Service, RCO-Remote Control Outlet, SFO-Single Frequency Outlet, SSO-Self Sustaining Outlet, EMER-Emergency Channel Capability (121.5 MHz), ASR-Airport Surveillance Radar, ARSR-Air Route Surveillance Radar, UHF-Ultra High Frequency, VHF-Very High Frequency. HIGH, LOW, TERMINAL, and VOICE are usually associated with VOR's, TACAN's and VORTAC's. LRCO, TWEB, EFAS, RCO, SFO, and SSO are usually associated with COMM facilities, ASR and ARSR with RADARS, and UHF & VHF with DF facilities. A particular site may be of more

than one type and class. The class field is 18 bits long and the meaning of each bit position is as follows:

Class	H	L	T	LRCO	VOICE	TWEB	EFAS	RCO	SFO	SSO	EMER	ASR
Bit	1	2	3	4	5	6	7	8	9	10	11	12

ARSR	UHF	VHF	NOT USED
13	14	15	16-18

An additional output of the program is a full record listing of each selected facility.

PROGRAM 2

Program 2 requires only one parameter card. This card specifies the topographic data required for the run and also allows the user to control how many sites (on the input tape) will be processed. This latter feature provides for segmentation where a larger number of sites is to be processed, and also enables the user to salvage useful information from a run that has been aborted due to excessive run time, system error, or tape malfunction. The specification for topographic data consists of the center point of the area of interest described by latitude and longitude, and a radius large enough to encompass the area plus the length of the longest profile expected. The format of the parameter card is as follows:

Col.	1 - 3	Latitude degrees of center point for topographic data selection
Col.	4 - 6	Latitude minutes of center point for topographic data selection
Col.	7	N/S - Hemisphere of latitude center point
Col.	9 -11	Longitude degrees of center point for topographic data selection

Col. 12-14	Longitude minutes of center point for topographic data selection
Col. 15	E/W - Hemisphere of longitude center point
Col. 17-19	Radius, in nautical miles, around center point for which topographic data is required
Col. 21-24	Number of records on the input tape that are to be skipped
Col. 26-29	Number of records to be processed
Col. 31	Always "1"

All fields are right justified.

The format of the input data (File A) is the format of the output data from Program 1. The output of this program (File B) is 14-word records, 100 records to a tape block, whose format is as follows:

Word 1, S3 to Word 2, S4 - Waypoint ID broken down as follows:

Word 1, S3-S5	Waypoint latitude code. The first two characters are the latitude of the waypoint in degrees. The third character is either: a blank, A, B, or C, indicating the 15-minute increment of 0, 15, 30 or 45 minutes respectively. Characters are in fieldata code.
Word 1, S6	Always a fieldata "/"
Word 2, S2-S4	Waypoint longitude code, described in the same manner as for latitude.

All waypoints are assumed to be north latitude and west longitude. An example of a waypoint ID is 45A/126C, which is 45° 15' N latitude and 126° 45' W longitude.

Word 2, S5 - Word 3, S2	Facility ID; call sign of the facility
Word 3, S3 - S5	Facility class; special binary code as described for Program 1

Word 3, S6	Facility type; special binary code as described for Program 1
Word 5, S3 - Word 6, S4	Latitude of the facility in decimal degrees. The decimal point is the third character
Word 6, S5 - Word 8, S1	Longitude of the facility in decimal degrees. The decimal point is the forth character
Word 8, S2 - S6	Site elevation, in feet at the facility
Word 9, S5 - Word 10, S3	Bearing, in degrees, from the facility to the waypoint
Word 11, S4 - Word 12, S2	Distance, in nautical miles, from the facility to the waypoint
Word 12, S4 - Word 13,S2	Minimum reception altitude (MRA) at the waypoint
Word 13, S3 - Word 14,S1	Terrain elevation at the waypoint
Word 14, S2	Flag. If this contains an "*" it indicates that there was missing profile elevation data, and the MRA was calculated using the last known profile elevation for the missing elevations.

All fields except class and type are in fieldata. The records on the output tape are ordered by waypoint ID. The program also produces a listing of each waypoint-facility record as it is generated.

PROGRAM 3

Program 3 is a merge program that merges the output of successive runs of Program 2 (Files A and B) and produces a waypoint-facility records-library tape (File C). There are no run parameter cards required for this program. The record formats for both input and output are identical to the output record format of Program 2. A message is printed at the end of the run indicating the number of records read from each input file and the number of records written in the output file.

PROGRAM 4

Program 4 provides the major outputs of the system, which are of three types: a listing, high-speed printer plots, and a tape used to generate a Calcomp contour-coverage map overlay. The program also has the capability to select records, by various criteria, from the waypoint-facility records-library tape (File A). These various options are indicated on parameter cards. The format of these cards is described below.

Option Card

Cols. 1 - 6 "OPTION"

Cols. 13 - 18 "SELECT" - Blank if select option not desired

Cols. 25 - 30 "LIST" - Left adjusted - blank if listing not desired

Cols. 37 - 42 "PLOT" - Left adjusted - blank if HSP plots not desired

Cols. 49 - 54 "TAPE" - Left adjusted - blank if Calcomp tape not desired

Cols. 61 - 72 12-character title to appear in the heading for the HSP plots

Parameter Select Cards

Geographic Select Card.

Cols. 1 - 3 "GEO"

Cols. 7 - 12 Northern latitude boundary of geographic area in decimal degrees. Decimal point in Col. 10

Cols. 19 - 24 Southern latitude boundary of geographic area in decimal degrees. Decimal point in Col. 22

Cols. 31 - 36 Eastern longitude boundary of geographic area in decimal degrees. Decimal point in Col. 34

Cols. 43 - 48 Western longitude boundary of geographic area in decimal degrees. Decimal point in Col. 46. All latitudes are assumed to be north and all longitudes west.

Type Select Card.

Cols. 1 - 4	"TYPE"
Cols. 12,18,24,30	Up to 4 facility type codes may be indicated for selection. First type code in Col. 12, second in Col. 18, etc.
	Type Codes are 1 = VOR, 2 = TACAN, 3 = VORTAC, 4 = DME, 5 = COMM, 6 = DF, 7 = RADAR

Operating Agency Select Card.

Cols. 1 - 4	"OWNER"
Cols. 12,18,24,30	Up to 4 operating agency codes may be indicated for selection. First operating agency code in Col. 12, second in Col. 18, etc.
	Operating Agency Codes are A = Air Force, F = FAA, N = Navy, R = Army, O = Other

Selection capabilities are built into the program for SITE I.D. and facility class. However, customer specifications for these select criteria have not been determined. Provision has been made for selection of up to 10 site ID's and 10 facility classes. The formats for these cards are:

Site Select Card.

Cols. 1 - 6	"SITEID"
Cols. 13 - 15	1st Site ID
Cols. 19 - 21	2nd Site ID
Cols. 25 - 27	3rd Site ID
Cols. 31 - 33	4th Site ID
Cols. 37 - 39	5th Site ID
Cols. 43 - 45	6th Site ID
Cols. 49 - 51	7th Site ID

Cols. 55 - 57 8th Site ID

Cols. 61 - 63 9th Site ID

Cols. 67 - 69 10th Site ID

Class Select Card.

Cols. 1 - 5 "CLASS"

Cols. 12, 18, 24, 30, 36, 42, 48, 54, 60, 66. Up to 10 site class codes may be indicated for selection. First class code in Col. 12, second in Col. 18, etc. Class codes are:

L = LRCO, V = VOICE, W = TWEB, E = EFAS, R = RCO, S = SFO, O = SSO, X = EMERGENCY, 1 = ARSR, 2 = ASR, A = VHF, B = UHF

At least one select parameter card is necessary if the "SELECT" option was indicated on the option card. No parameter card is necessary for the "LIST" option. If the "PLOT" option is desired, a parameter card designating the altitudes for which HSP plots are wanted is necessary. The format of this card is:

Cols. 1 - 6 "HEIGHT"

Cols. 7 - 12 Altitude in feet for 1st HSP Coverage Plot

Cols. 13 - 18 Altitude in feet for 2nd HSP Coverage Plot

Cols. 19 - 24 Altitude in feet for 3rd HSP Coverage Plot

Cols. 25 - 30 Altitude in feet for 4th HSP Coverage Plot

Cols. 31 - 36 Altitude in feet for 5th HSP Coverage Plot

Cols. 37 - 42 Altitude in feet for 6th HSP Coverage Plot

Cols. 43 - 48 Altitude in feet for 7th HSP Coverage Plot

Cols. 49 - 54 Altitude in feet for 8th HSP Coverage Plot

Cols. 55 - 60 Altitude in feet for 9th HSP Coverage Plot

Cols. 61 - 66 Altitude in feet for 10th HSP Coverage Plot.

As many coverage plots will be produced as there are altitudes on the "HEIGHT" card. The least MRA plot is produced if the "PLOT" or "TAPES" option is indicated. The "TAPE" option will produce an output tape,

in matrix form, of numerical values of the character codes used in the least MRA. HSP plot. This tape is the input to Program 5, which will produce a Calcomp plotter control tape. The parameter card necessary for the "TAPE" option is a follows:

Cols. 1 - 6	"PLTLAB"
Cols. 7 - 8	Latitude degrees of center of contour plot
Cols. 9 - 10	Latitude minute
Cols. 11 - 12	Latitude seconds
Cols. 13	N or S latitude hemisphere
Cols. 19 - 21	Longitude degrees of center of contour plot
Cols. 22 - 23	Longitude minutes
Cols. 24 - 25	Longitude seconds
Cols. 26	E or W longitude hemisphere
Cols. 31 - 38	Overlay map scale in inches.

There is no order priority to the card sequence. The record format of the output matrix tape (File B) is very straightforward. The record length, in words, is equal to the number of columns in the least MRA plot. Each word is a numerical floating-point value of the character code for that column in the row. Each row is a record and there are ten records to a tape block. The first record on the tape is the heading record, which contains the data from the "PLTLAB" parameter card in fieldata code.

PROGRAM 5

Program 5 produces a Calcomp plotter control tape (File 2). The input data is on the output tape of Program 4 (File A). The Calcomp plot will be drawn at a specified scale and for a Lambert Conformal map projection. The parameter cards are as follows:

Card 1.

Col. 2	Always "1"
Cols. 4 - 6	Number of rows in input matrix
Cols. 8 - 10	Number of columns in input matrix
Cols.12 - 19	Spacing in inches between columns in matrix at map scale; i.e., if the geographic spacing between columns is 15 minutes of longitude and the map scale is 1:2,334,720, the spacing is .34382 inches (1" = 45 minutes, approximately); decimal point included in field.
Cols.21 - 28	Spacing in inches between rows in matrix at map scale
Cols.31 - 32	Number of contour levels desired
Col. 34	If "1," control levels will be given on card 2. If not equal to "1," the levels will be calculated by the program.
Cols.36 - 43	Map Scale, associated with spacing in inches (see above). If map scale is 1:250,000, the value put in this field is 250,000
Col. 54	Pen option indicator. "1" = change pen color at each contour level. (Program will repeat colors every three contours.) "2" = change pen color at specified contour levels.
Cols.48 - 65	Contour level at which to make 1st pen change (use decimal point)
Cols.67 - 74	Contour level at which to make 2nd pen change
Col. 76	Blank = Contour levels identified by letters "1" = Contour levels identified by numbers.

Card 2.

Cols. 2 - 8	Contour Level 1
Cols.10 - 16	Contour Level 2
.	
.	
.	
Cols.74 - 80	Contour Level 10 Contour levels are 7-character fields, 1 character between fields. Levels are in feet. Use Decimal point.

Card 3.

Cols. 2 - 11 Latitude of center of plot (decimal degrees)

Cols. 12 - 21 Longitude of center of plot (decimal degrees, west longitude is minus)

Cols. 22 - 31 Lower standard parallel of latitude, for Lambert Conformal projection (decimal degrees)

Cols. 32 - 41 Upper standard parallel of latitude for Lambert Conformal projection (decimal degrees).

Card 4.

Cols. 2 - 61 Optional 60-character title to appear on plot.